On the Influence from Insulating Layers on Measurements of Thermal Transport Properties of Electrically Conducting Solids and Fluids with Plane Source Sensors

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When measuring the thermal transport properties of electrically conducting solids and fluids, plane source sensors, covered with electrically insulating layers, are being used for a substantial number of applications. The influence of these insulating layers on the measurements has so far been described as the development of a constant temperature difference between the sensing material and the nearest surface inside the sample having bulk properties. By selecting a conveniently small thickness of these layers, the time it takes for the temperature difference to become constant can be kept short compared with the transient event used for measuring the bulk properties of the sample.

It is generally accepted that the time it takes to establish a constant temperature difference across a slab is proportional to δ^2/κ, where δ is the thickness and κ is the thermal diffusivity of the layer. Sensors are commonly in use for which the insulating layers, covering the sensing material, are approximately 25 μm thick with a thermal diffusivity of around 0.1 mm²/s. For this kind of insulating layer, the time (δ^2/κ) would be around 6 ms. At present there are insulating materials with a thermal diffusivity as high as 100 mm²/s, and looking only at the temperature difference, it would actually imply, that it might be possible to work with mm size layers of these high conducting materials. However, a thick high conducting layer will alter the temperature distribution in the sensor and the sample throughout the transient in a way that has to be considered when evaluating the transport properties. Ways and means of dealing with these deviations in recent work with the hot disk thermal constants analyzer will be described and discussed.